L-R IR Design Aspects

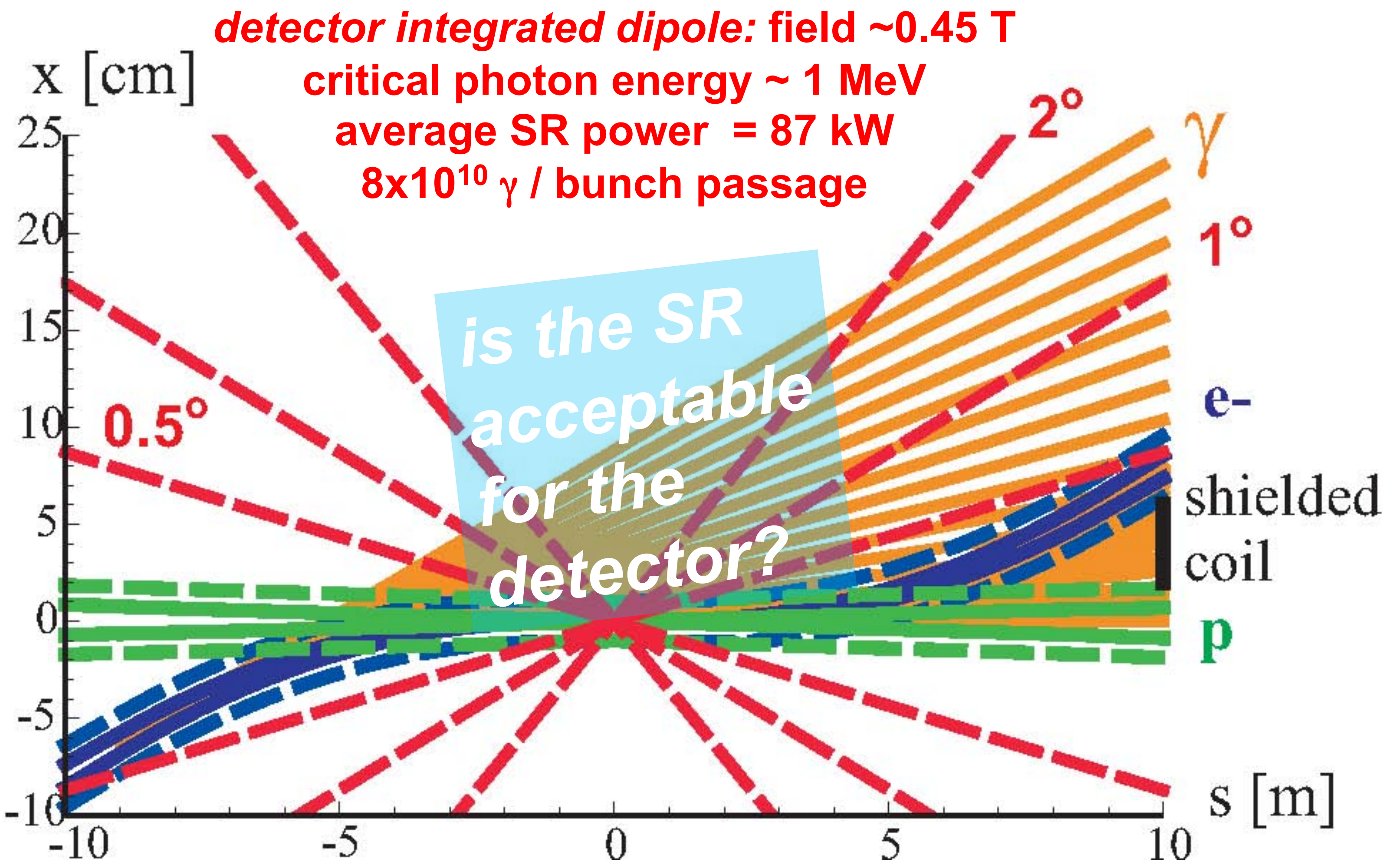
- crossing angle
- magnets
- second proton beam
- beam optics
- beam pipe design and dimensions

Rogelio Tomas, Frank Zimmermann

Special LHeC Meeting

4 October 2010

L-R IR layout (May 2010)



beam envelopes of 10σ (electrons) [solid blue] or 11σ (protons) [solid green], the same envelopes with an additional constant margin of 10 mm [dashed], the synchrotron-radiation fan [orange], and the approximate location of the magnet coil between incoming protons and outgoing electron beam [black]

L-R IR optics (Divonne '09)

R. Tomas

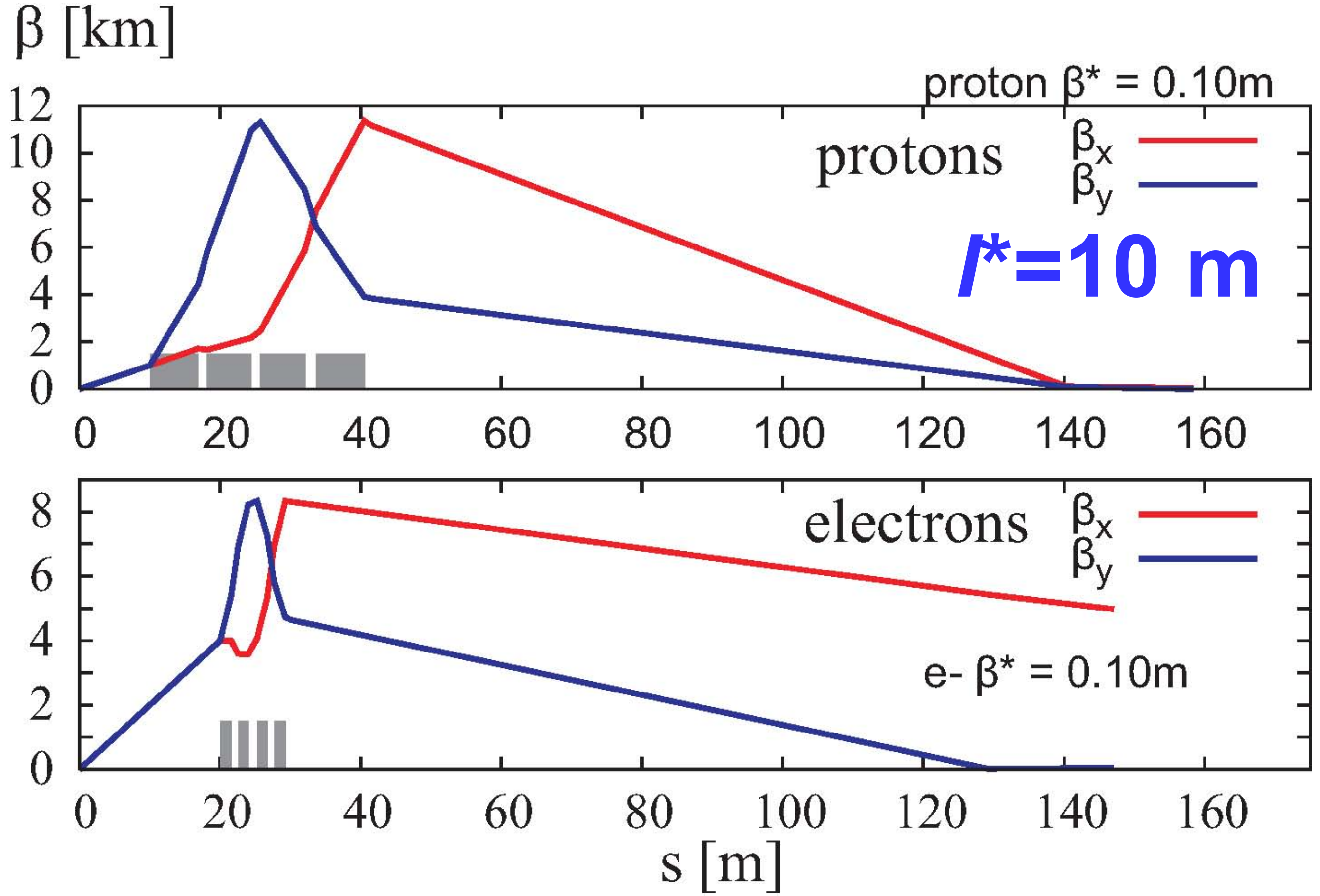


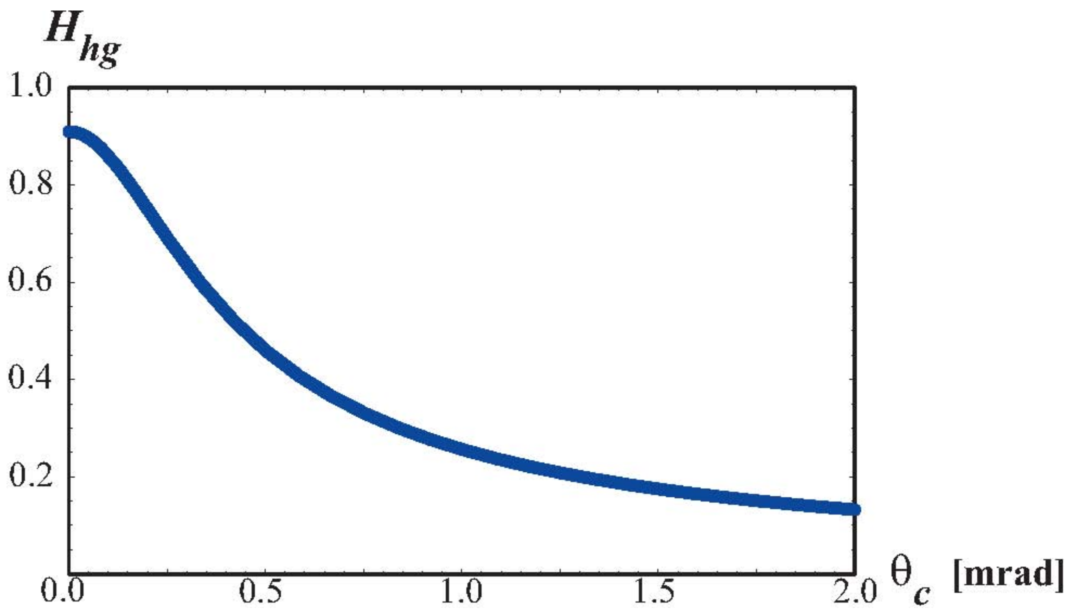
Table 2: Parameters of the first two proton quadrupoles [4].

magnet	pipe radius	gradient	field at pipe
Q1	26 mm	318.6 T/m	8.4 T
Q2	36 mm	250.0 T/m	9.1 T

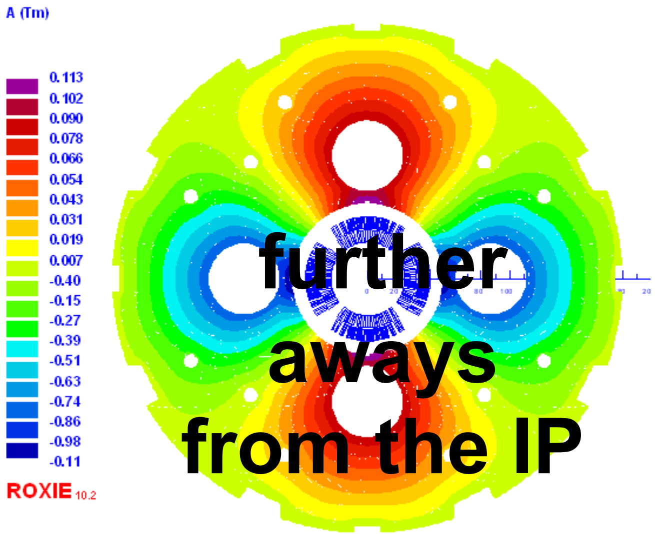
crossing angle

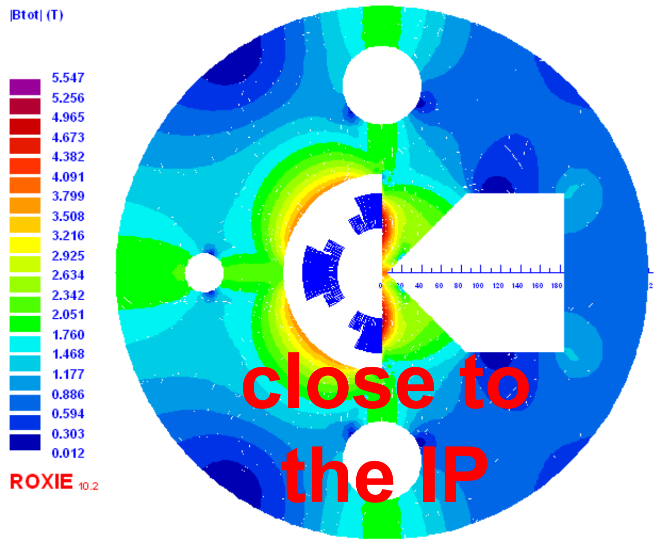
zero crossing angle, head-on collision:

– we need to separate beams by 6-9 cm at 10 m from IP (i.e. 6-9 mrad) [constraint from magnet design]
– crab cavities ruled out [20-30x HL-LHC crab voltage]
– maximum allowed crossing angle for luminosity < 0.5 mrad (see graph)



quadrupole magnets





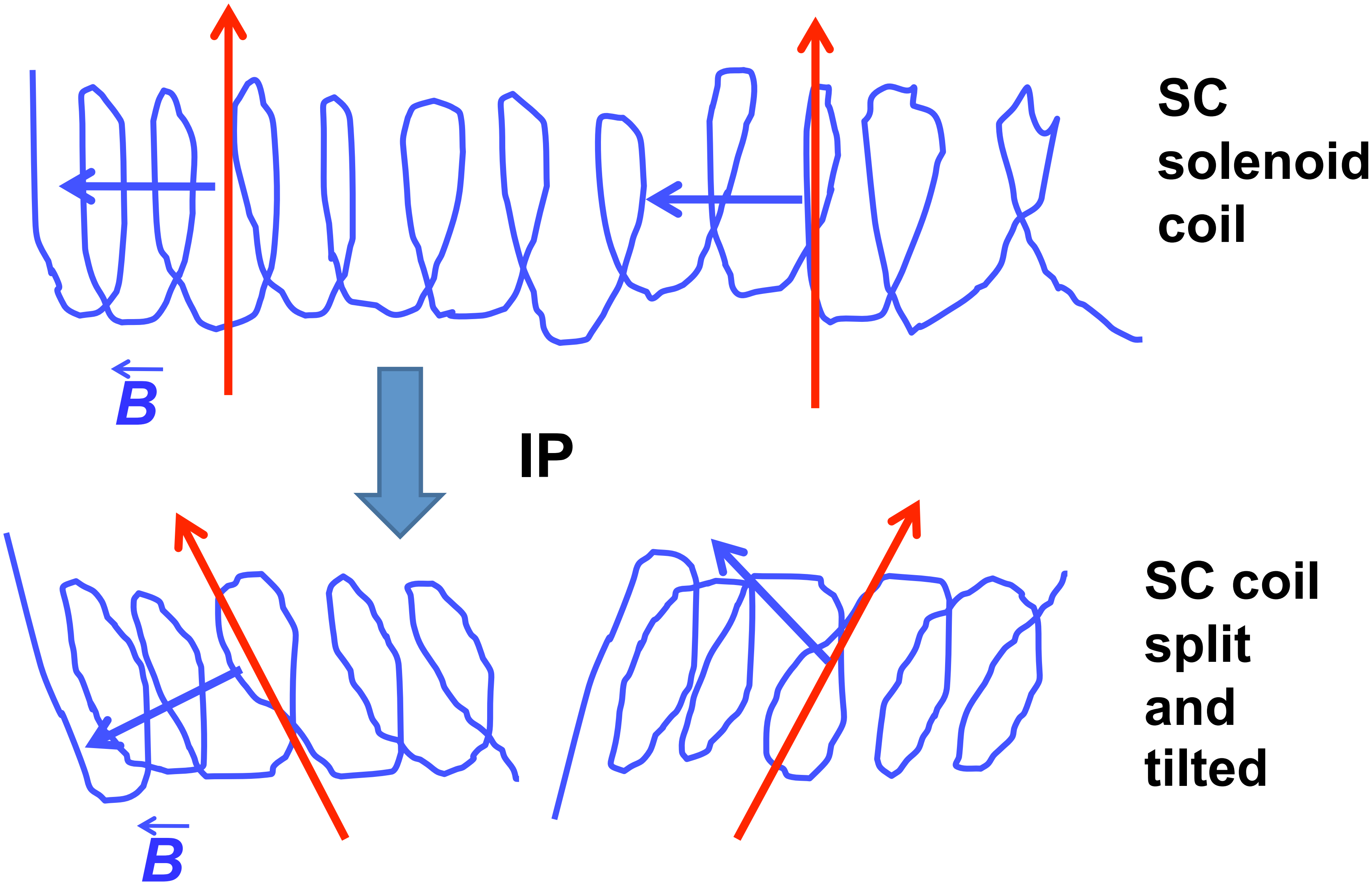
NbTi: 6700 A, 248 T/m at 88% LL	NbTi: 4500 A, 145 T/m, 3.6 T at 87%
Nb3Sn (HFM46): 8600 A, 311 T/m, at 83% LL	Nb3Sn (HFM46): 5700 A, 175 T/m, 4.7 T at 82% on LL (4 layers)
23 mm app. 87 mm beam sep.	46 mm (half) app. 63 mm beam sep.
0.03 T, 3.5 T/m 0.09 T, 9 T/m	0.37 T, 18 T/m 0.5 T, 25 T/m

NbTi at 1.8 K, Nb3Sn at 4.2 K

Stephan Russenschuck

We consider Nb3Sn, and plan to use both these magnets! Rogelio Tomas, Frank Z.

detector integrated dipole



Stephan Russenschuck, Simona Bettoni, Eugenio Paoloni

detector integrated dipole

9 m long (per side of IP, before: 7.5 m)

total deflection angle 13.6 mrad

0.3 T (before: 0.45 T)

- critical photon energy ~700 keV
- average SR power ~ 60 kW
- 5×10^{10} γ's/bunch passage

second proton beam

design considerations (Rogelio & Frank, Sept.'10):

– separate pipe should avoid ~1-m radius around IP

– it is difficult to separate 7-TeV beams by 1 m (many long strong bends)

– circumferences for beam 1 & 2 need to be matched

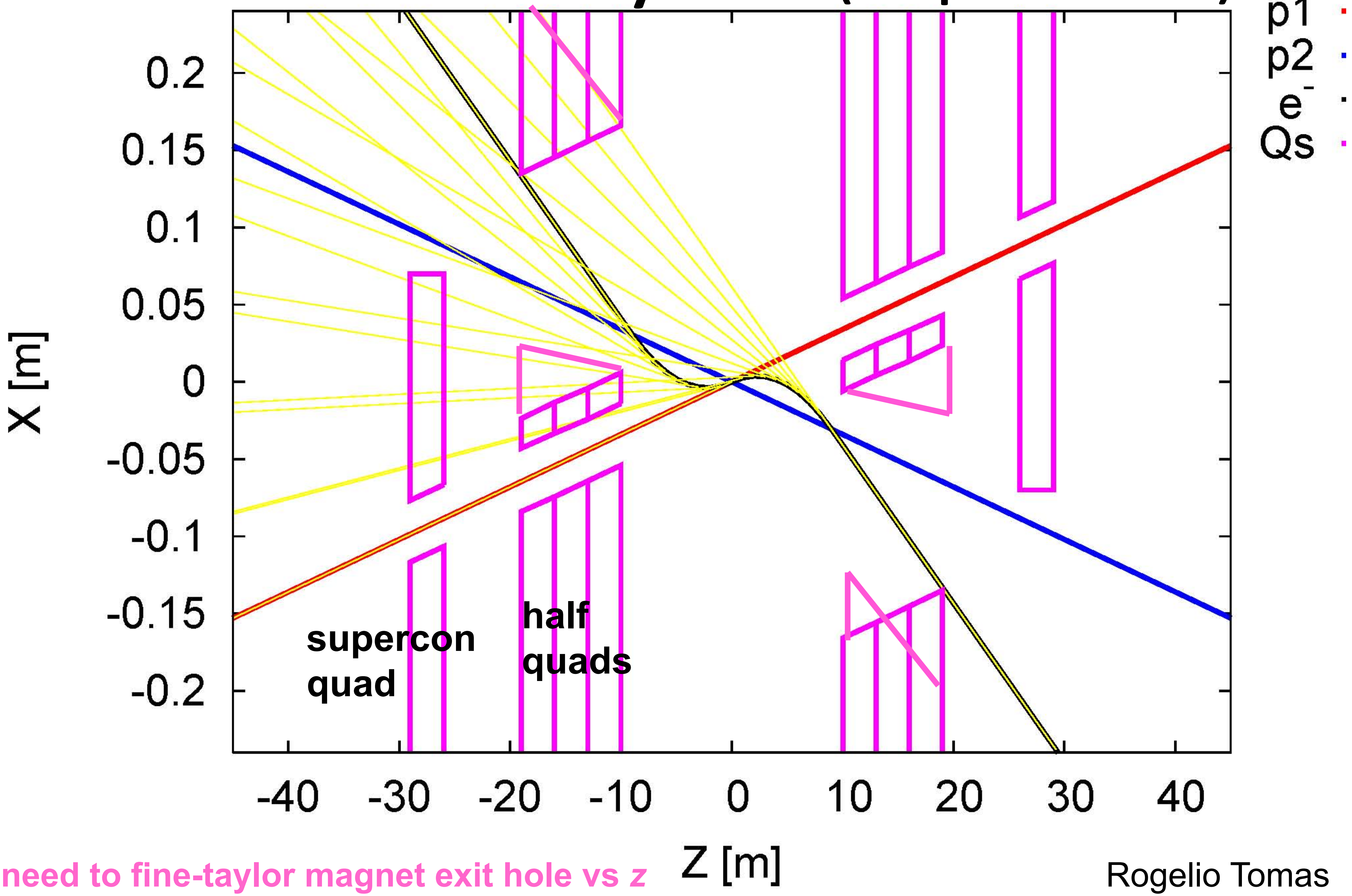
→ preserving present configuration may be best (and only) solution; pass 2nd beam through IP region

– but we need quad aperture for 1st beam and low β^*

→idea to pass 2nd beam through e- beam exit hole (separation and angle about right)

– we might even eliminate one dipole magnet per side (correcting residual dispersion if needed)

new L-R IR layout (Sept. 2010)



need to fine-taylor magnet exit hole vs *z*

Rogelio Tomas

aperture

asymmetric aperture favored;

at +/- 6 m from IP one needs:

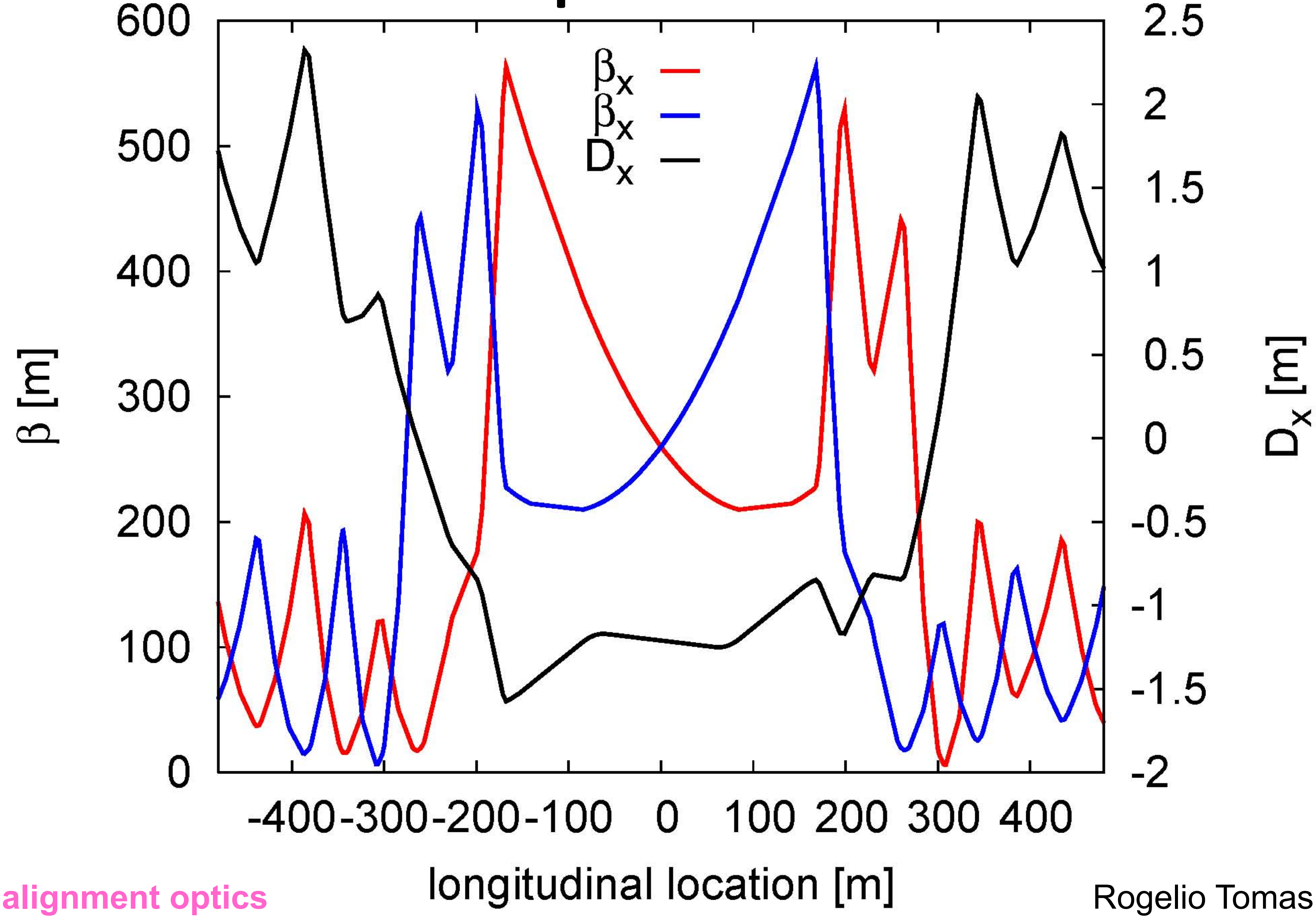
- 2 cm half aperture in y
- horizontal half aperture must accommodate *p-p* crossing angle of ~6 mrad and SR fan (one quadrant only)

  ~5 cm in 3 quadrants

  ~10 cm in last quadrant

one could taper the IR beam pipe and get closer towards the IP

second proton beam



alignment optics

Rogelio Tomas

conclusions

solution for three beams which complies with known constraints and exploits latest magnet design

SR somewhat less severe than before

<u>still needed:</u>

design of detector-integrated dipole

fine-tuning of IR quadrupoles (different segments)

matched optics for *p* B1, re-matched optics for B2

matched optics for e- beam

detailed SR shielding & masking:

- assessment of SR detector impact
- assessment of Q1 heat load from SR